CIRCULAR No. 113. Issued November 13, 1909.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

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THE CHINCH BUG.

(*Blissus leucopterus* Say.)

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INTRODUCTION.

Few insects, and certainly no other species of the natural order to which this one belongs, have caused such enormous pecuniary losses as has the chinch bug (*Blissus leucopterus* Say) (fig. 1). No other insect native to the Western Hemisphere has spread its devastating hordes over a wider area of country (see map, fig. 7) with more fatal effects to the staple grains of North America than has this one. But for the extreme susceptibility of the very young to destruction by drenching rains and to the less, though not insignificant, fatal effect during rainy seasons of the parasitic fungus *Sporotrichum globuliferum* Speg., on both the adults and young, the practice of raising grain year after year on the same areas, as is followed in some parts of the United States, would become altogether unprofitable. Some of this insect's own habits, emphasizing as they do the effects of meteorological conditions, are among the most potent influences that serve to hold it within bounds by giving its tendency to excessive increase a decidedly spasmodic character.

FIG. 1.—Chinch bug (*Blissus leucopterus*): Adult of long-winged form, much enlarged. (Author's illustration.)

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DESCRIPTIONS OF THE DIFFERENT STAGES.

The egg (fig. 3, *a*, *b*).—The average length of the egg is three one-hundredths of an inch; in shape it is elongate-oval, the diameter being scarcely one-fifth the length. The top is squarely docked and surmounted with four small, rounded tubercles near the center.

FIG. 2.—Chinch bug: Adults of short-winged form, much enlarged. (Author's illustration.)

When newly deposited the egg is pale or whitish and translucent, but with age it acquires an amber color, and finally shows the red parts of the embryo within, and especially the eyes toward the tubercled end. The size increases somewhat after deposition, and the length will sometimes reach nearly four one-hundredths of an inch.

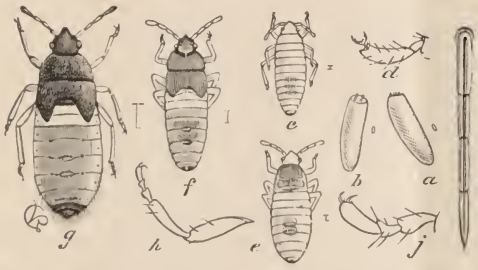

FIG. 3.—Chinch bug: *a*, *b*, Eggs; *c*, newly hatched larva, or nymph; *d*, its tarsus; *e*, larva after first molt; *f*, same after second molt; *g*, last-stage larva; the natural sizes indicated at sides; *h*, enlarged leg of perfect bug; *j*, tarsus of same, still more enlarged; *i*, proboscis or beak, enlarged. (From Riley.)

Larval stages (fig. 3, *c*, *d*, *e*, *f*).—The newly hatched larva, or nymph, is pale yellow, with simply an orange stain on the middle of the three larger abdominal joints. The form scarcely differs from that of the mature bug, being but slightly more elongate; but the tarsi have only two joints, and the head is relatively broader and more rounded, while the joints of the body are subequal, the prothoracic joint being but slightly longer than any of the rest. The red color soon pervades the whole body, except the first two abdominal joints, which remain yellowish, and the legs and antennæ, which remain pale.

After the first molt the red becomes bright vermilion, contrasting strongly with the pale band across the middle of the body, the prothoracic joint is relatively longer, and the metathoracic shorter. The

head and prothorax are dusky and coriaceous, and two broad marks on mesothorax, two smaller ones on metathorax, two on the fourth and fifth abdominal sutures, and one at tip of abdomen are generally visible, but sometimes obsolete; the third and fourth joints of antennæ are dusky, but the legs are still pale. After the second molt the head and thorax are quite dusky and the abdomen duller red, but the pale transverse band is still distinct; the wing-pads become apparent, the members are more dusky, there is a dark-red shade on the fourth and fifth abdominal joints, and, ventrally, a distinct circular dusky spot, covering the last three joints.

The last-stage larva (fig. 3, *g*).—In the last-stage larva, or nymph, sometimes called the "pupa," all the coriaceous parts are brown-black, the wing-pads extend almost across the two pale abdominal joints, which are now more dingy, while the general color of the abdomen is dingy gray; the body above is slightly pubescent, the members are colored as in the mature bug, the three-jointed tarsus is foreshadowed, and the dark horny spots at tip of abdomen, both above and below, are larger.

The adult.—There are two forms of the fully developed insect, but it is not known that the young of these two forms differ in any respect. One of these forms is known as the long-winged form and is the only form that occurs over most of the country between the Rocky Mountains and the Allegheny Mountains, and is the one originally described. This form is illustrated in figure 1.

The second form is much like the first, with the exception of the wings, which are more or less abbreviated, as shown in figure 2. This form occurs along the seacoasts and in the East extends inland along the lower lakes to northern Illinois. It is not abundant, however, west of a line drawn from Toledo, Ohio, to Pittsburg, Pa. Throughout the territory in which this short-winged form is found there are also intermingled with them individuals of the long-winged form. Both of these forms may be described as black, with numerous hairs also black, and with the under wings white. The upper wings are whitish, with a black spot on each. They are about one-fifth of an inch or less in length and may be easily recognized by the accompanying illustrations (figs. 1, 2, 3, *h*, *i*, *j*).

SEASONAL HISTORY.

Over the territory covered by the long-winged form, as previously given, the insect has two generations each year. The young of the first generation appear in May and June, and those of the second generation in August and perhaps as late as September. The adult insects (figs. 1, 2) pass the winter among matted grass, fallen leaves, and other rubbish, and come forth from their hiding in spring and

spread to the grain field, where they deposit their eggs. After the eggs are hatched the old bugs die, and the young hatching from these

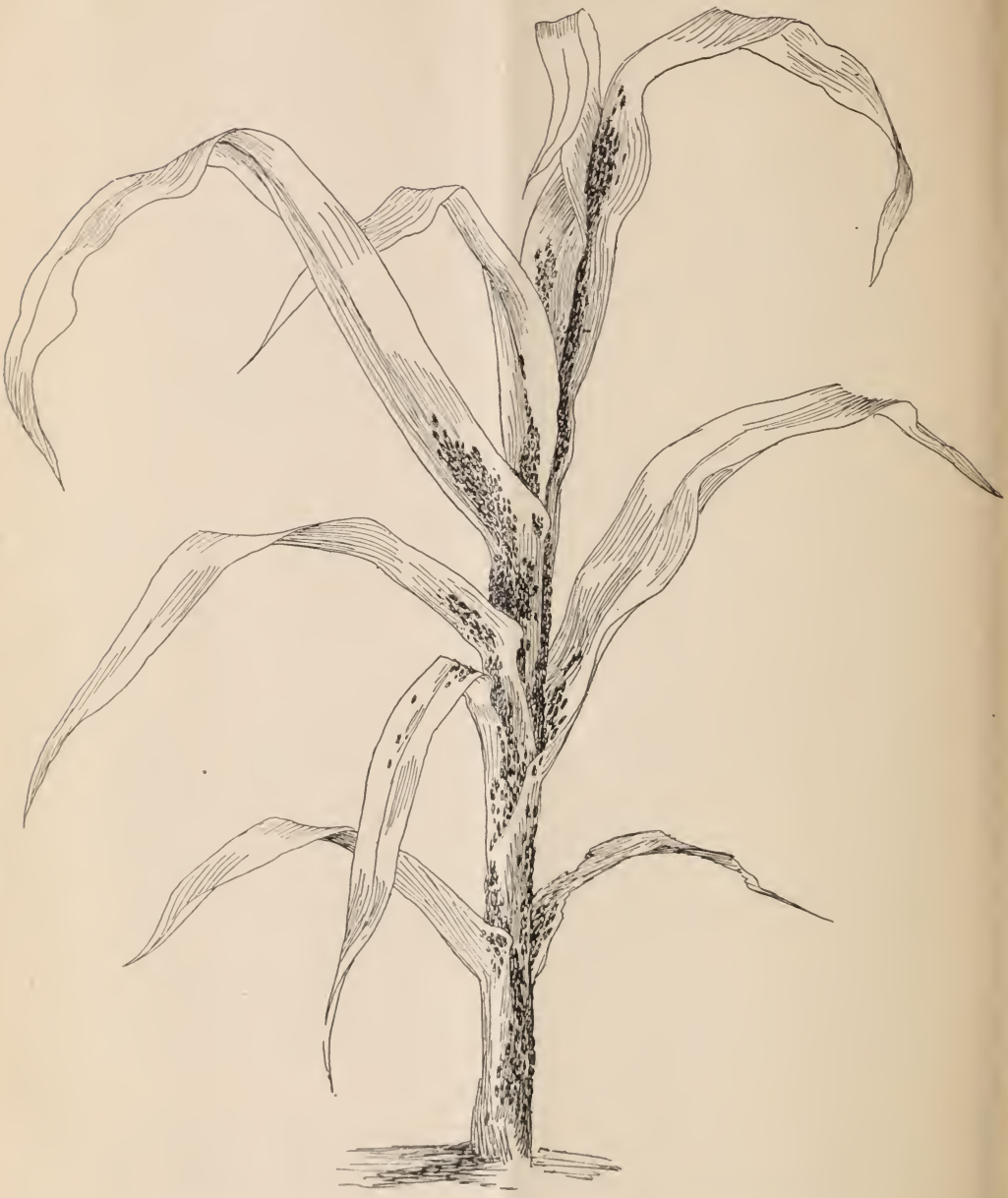

FIG. 4.—Corn plant 2 feet tall infested with chinch bugs. (Author's illustration.)

eggs cluster upon the plants and begin at once to live upon the juices. Figure 4 illustrates a corn plant with the chinch bugs clustering upon it. The egg-laying season extends over a considerable period

and chinch bugs of all ages, sizes, and colors are found intermingled. By August the majority of the first generation have reached the adult stage, at which time the eggs are deposited for the second generation, which hatches and matures like the previous one, nearly all individuals reaching their full development by late fall or early winter.

In the eastern portion of the country, where the short-winged form prevails, it is doubtful if there is more than a single generation annually. This short-winged form differs very much in its habits from the long-winged form, the first passing the winter in the meadows, which it usually attacks in preference to grain crops, while with the long-winged form, during the period known as the Indian summer, the developed bugs may be observed flying about, evidently searching for winter quarters. With the short-winged form these migrations to and from the places of hibernation are impossible, the insects being totally incapable of flying because of their short wings. A hint of this characteristic may be witnessed in the case of the exclusively long-winged form, for in migrating from one field to another, even though fully half of the individuals may have fully developed wings, ample for flight, they often travel on foot with the young, even going considerable distances from one field to another.

Throughout the Middle West, then, where this insect does its greatest injury, the crops suffer from two attacks annually, although the later one is seldom noticed. It must be remembered, however, that, although attracting little or no attention, this later attack is of the utmost importance, for, if there are but few of the second generation developing to adults, there can be no serious outbreak the following spring. If, on the other hand, there are enormous numbers of adults developing in the fall and going into winter quarters, there is a probability that, with weather during April and May favorable for their development, there will be an excessive abundance the following year.

It must be remembered that each female of the species is capable of laying from 1 to 500 eggs, and she will scatter them during a period of from two to three weeks. The time required for the eggs to hatch is from about ten days to three weeks, and it requires about forty days for the young to become fully developed after hatching from the egg.

HIBERNATION.

While the matter of winter quarters has been previously mentioned in a general way, the winter habit of the pest is of such importance that this phase of its life history is deserving of full explanation. Again and again serious and destructive outbreaks of the pest in wheat fields have been traced directly to the influence of shocks of corn fodder allowed to stand in the fields throughout the winter. The chinch bugs which flocked to these corn shocks the previous autumn

were protected throughout the winter, migrating from them in the spring and spreading over the wheat field. In other cases destructive outbreaks have been traced directly to woodlands bordering upon the fields, the chinch bugs beginning their destruction along the margins of the fields nearest to the woodlands, having passed the winter among the fallen leaves. So, too, have destructive outbreaks in the Middle West been traced to the matted grass and fallen leaves bordering hedges of Osage orange (fig. 5). The farmer must understand that it is to such places as these that the chinch bugs flock in the fall, and whatever measures can be effected to prevent their wintering

FIG. 5.—A road between two farms, with neglected hedges on either side affording ample protection for destructive insects during winter. (Author's illustration).

about his fields in this manner will be measures of protection to his crop from attacks of their offspring in the following year.

In the timothy meadows of New England, New York, and northern Ohio these conditions are of less importance, because there the insects pass the winter largely in the meadows themselves, and do not migrate to or from these places, except to travel on foot. Chinch bugs will stand almost any degree of cold, provided it is continuous and they are fairly well protected from sudden changes. Thus it is that the farmer may be able to take advantage of their hibernation to deal a disastrous blow to their occurrence in his fields during late spring and early summer.

FOOD PLANTS.

Over the western country the major portion of the damage is that accomplished in fields of wheat, barley, rye, and corn, the outbreak generally originating in wheat or barley fields and the bugs migrating at harvest to the cornfields. In the eastern part of the country, where the timothy meadows are the most seriously infested, this is not the case, and here the migrations are as likely to be to the timothy meadows as to the fields of corn where both are equally within reach. Rye and oats are less liable to infestation. The chinch bugs attack sugar cane in Mexico, according to Mr. Albert Koebele. They are known to attack the following grasses: Forked beard-grass (*Andropogon furcatus*), broom beard-grass (*A. scoparius*), oat-grass (*Arrhenatherum*), bur-grass (*Cenchrus tribuloides*), millet, witch grass (*Panicum capillare*), barnyard grass (*Panicum crus-galli*), *Phragmites* sp?, sorghum, kaffir corn, large crab-grass (*Syntherisma sanguinalis*), timothy, yellow foxtail (*Ixophorus glaucus*), green foxtail-grass (*I. viridis*), Bermuda grass (*Capriola dactylon*), and what is locally known in Florida as St. Augustine grass. Prof. Lawrence Bruner has also found it feeding upon so-called buckwheat (*Polygonum dumetorum* or *P. convolvulus*).

It will thus be seen that the insect has an ample food supply outside of the cultivated fields.

LOSSES CAUSED BY CHINCH BUGS.

It would appear that this pest first made its presence known by its ravages in the wheat fields of the North Carolina farmers, for we are told that "in 1785 the fields in this State were so overrun with them as to threaten a total destruction of the grain. And at length the crops were so destroyed in some districts that farmers were obliged to abandon the sowing of wheat. It was four or five years that they continued so numerous at this time."[a]

In the year 1809, as stated by Mr. J. W. Jefferys,[b] the chinch bug again became destructive in North Carolina to such an extent that in Orange County farmers were obliged to suspend the sowing of wheat for two years. In 1839[c] the pest again became destructive in the Carolinas and in Virginia, where the bugs migrated from the wheat fields at harvest to the corn, and in 1840 there was a similar outbreak, and both wheat and corn were seriously injured. In all of these cases, however, there is no recorded estimate of the actual financial losses resulting from the attacks of the chinch bug. According to Le Baron,

[a] Webster on Pestilence, Vol. I, p. 279. Not seen. Quoted from Fitch.
[b] Albany Cultivator, first series, Vol. VI, p. 201.
[c] The Cultivator, Vol. VI, p. 103.

during the years from 1845 to 1850 the insect ravaged Illinois and portions of Indiana and Wisconsin, and in 1854 and 1855 it again worked serious injury in northern Illinois. The writer's earliest recollection of the chinch bug and its ravages in the grain fields of the settlers on the prairies dates from this last outbreak. Mr. B. D. Walsh estimated the loss to the farmers of Illinois in 1850 at $4,000,000, or $4.70 to every man, woman, and child living in the State.

In 1863, 1864, and 1865 the insect was again destructive in Illinois and other Western States, its ravages being especially severe in 1864, when we have another attempt at computation of the financial loss. Dr. Henry Shimer, of Mount Carroll, Ill., who had carefully studied the chinch bug, estimated that "three-fourths of the wheat and one-half of the corn crop were destroyed by the pest throughout many extensive districts, comprising almost the entire Northwest." In criticizing the doctor regarding another point, Walsh and Riley[a] admit that the estimate was "a reasonable one," and, taking it as a basis, with the actual cash price per bushel, computed the loss at about 30,000,000 bushels of wheat and 138,000,000 bushels of corn, with a total value of both amounting to over $73,000,000. Of course, all computations of this sort are necessarily only approximately correct, but there is more likelihood of an underestimate than of an overestimate in this case.

There was a serious outbreak of the chinch bug in the West in the year 1868, and again in 1871, but in 1874 the ravages were both widespread and enormous. Le Baron computed the loss in 1871 in seven States, viz, Iowa, Missouri, Illinois, Kansas, Nebraska, Wisconsin, and Indiana, at $30,000,000.[b] Riley computed the loss in Missouri alone in the year 1874 at $19,000,000, and added the statement that for the area covered by Le Baron's estimates in 1871 the loss in 1874 might safely be put down as double, or upward of $60,000,000.[c] Dr. Cyrus Thomas, however, estimates the loss to the whole country for the same year at upward of $100,000,000.[d]

The next serious outbreak of the chinch bug of which we have an estimate of the losses occurred in 1887, and covered more or less territory in the States of Kentucky, Ohio, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, and Kansas. In this case the damage was estimated by the United States statistician, Mr. J. R. Dodge, at $60,000,000, the heaviest losses occurring in Illinois, Iowa, Missouri, and Kansas.[e] This gives us as the estimated loss in the thirty-eight

[a] American Entomologist, Vol. I, p. 197, 1869.

[b] Second Report State Entomologist of Illinois, p. 144.

[c] Seventh Report State Entomologist of Missouri, pp. 24–25.

[d] Bulletin No. 5, U. S. Entomological Commission, p. 7.

[e] Report of U. S. Commissioner of Agriculture for 1887, p. 56.

years from 1850 to 1887, both inclusive, the enormous sum of $267,000,000.

There was a serious outbreak in Kansas, Iowa, Minnesota, and Illinois, having its beginning probably as early as 1892, but reaching its maximum severity, as in Ohio, in 1896. The loss in Ohio during the years 1894, 1895, 1896, and 1897 could not have fallen far short of $2,000,000. If we could have careful estimates of the loss during the last fifteen years it would in all probability swell the amount to considerably in excess of $350,000,000 for the period from 1850 to 1909. (See map, fig. 6.)

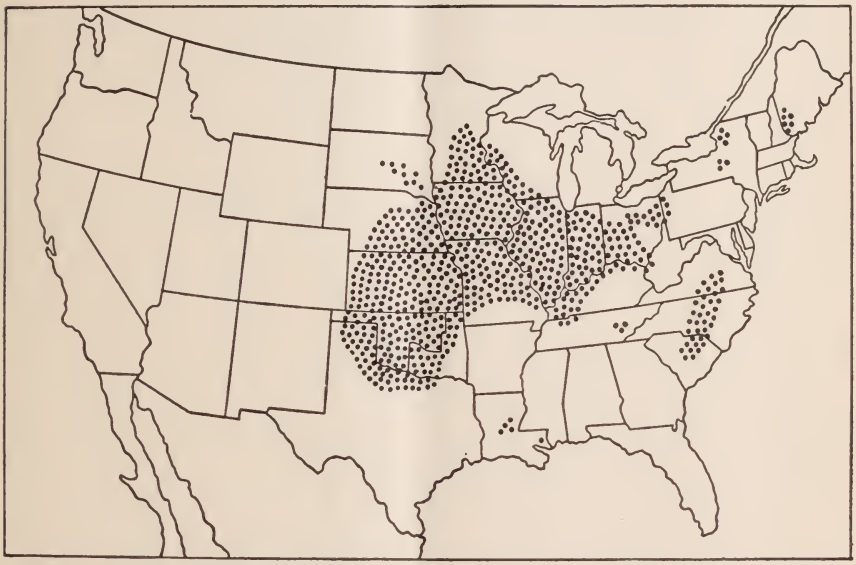

FIG. 6.—Areas in the United States over which the chinch bug occurs in most destructive numbers. (Author's illustration.)

NATURAL ENEMIES OF THE CHINCH BUG.

Chinch bugs have few natural enemies, none of which, owing, perhaps, to their repugnant odor, appears to be of any very great importance when it comes to suppressing a serious invasion. They are far more fortunate than most insects in escaping the attacks of natural enemies that exert a tremendous influence in holding other species in check.

THE BOBWHITE OR QUAIL.

Inland, the common "quail" or bobwhite (*Colinus virginianus*) is the only bird that can be said to devour the chinch bug in considerable numbers. It is said that from 300 to 400 chinch bugs have been found in the crops of bobwhites; 100, however, is the largest number found so far by the Biological Survey. As the bobwhite is one of

our most highly prized game birds, it is slaughtered annually in tremendous numbers, frequently with no other object in view excepting for gain. Some also are killed by flying against electric wires, while during severe winters entire coveys are sometimes smothered or frozen under the snow. As a result, the helpfulness of the quail against chinch bugs is greatly diminished. It would seem that as important an enemy of the chinch bug as this bird is known to be would receive protective immunity throughout the agricultural regions and that farmers would see to it that protective laws were not only enacted but also stringently enforced.

The following list will show the degree of protection offered the quail by legislative enactment in the States where the chinch bug is the most destructive (see map, fig. 6). The close seasons for quail in the several States, during which killing is prohibited by law, are as follows:[a]

Maine, all the year.
New York, December 1 to November 1, except in Dutchess, Putnam, Richmond, Rockland, and Westchester counties, where it is closed until 1910.
Pennsylvania, November 15 to October 15.
Ohio, December 5 to November 15.
Indiana, January 1 to November 10.
Illinois, December 10 to November 11.
Minnesota, December 1 to October 1.
Iowa, December 15 to November 1.
Missouri, January 1 to November 1.
Nebraska, all the year.
Kansas, December 15 to November 15.
Oklahoma, February 1 to November 15.
Texas, February 1 to November 1.

The breeding season from latitude 38° northward to Canada begins in May and continues through July and occasionally into September.

OTHER BIRD ENEMIES.

To what extent the birds of the coast region feed upon the chinch bug it is impossible to say. However, among the bird enemies of the pest are the prairie chicken, redwing blackbird, catbird, brown thrush or thrasher, meadowlark, house wren, tree swallow, horned lark, Arkansas kingbird, Traill flycatcher, seaside sparrow, savanna sparrow, song sparrow, tree sparrow, and barn swallow.

THE FROG.

Dr. Cyrus Thomas quotes Ross and others as stating that the common frog is an enemy of the chinch bug. While this is probably true, it is nevertheless well known that comparatively few frogs frequent grain fields, as a rule, and thus the benefit derived from their attacks is of too little importance to merit further notice.

[a] From Farmers' Bulletin No. 376, pp. 18–29, 1909.

INSECT ENEMIES.

Of the invertebrate enemies of the chinch bug the same may be said as of the frog. The writer has occasionally found a chinch bug containing a species of Mermis, or "hair snake." Occasionally, also, ants may be seen dragging these bugs away, while lady-beetles have sometimes been found to devour them, as recorded by Walsh and Forbes. Perhaps the worst insect enemies of the chinch bug are to be found among its comparatively near relatives—the insidious flower bug (*Triphleps insidiosus* Say), (*Anthocoris pseudo-chinche* of Fitch's Second Report), and *Milyas cinctus* Fab., the latter being reported by Thomas as the most efficient of the insect enemies of this pest, while Riley found that the former also attacked it. Professor Forbes ascertained, by examinations of the contents of the stomach of a ground beetle (*Agonoderus pallipes* Fab.), that one-fifth of the total food of this species was composed of chinch bugs. Shimer and Walsh both claim that lacewing flies (*Chrysopa* spp.) destroy chinch bugs, and they are doubtless correct. The writer has also very often found dead chinch bugs entangled in spider webs, although whether killed for food or by accident it has been impossible to determine.

NATURAL CHECKS OTHER THAN ANIMALS.

There are two natural checks to the increase of the chinch bug other than animal enemies. One of these is vegetable in nature, being a fungus, the other meteorological, and the interrelation of the two is so close that the former is almost entirely dependent upon the latter. It will at once be seen that the chinch bug, occurring, as it does, from but little north of the equator to nearly a latitude of 50° north and from an elevation of upward of 200 feet above the sea level in the Imperial Valley of southern California to an elevation of upward of 6,000 feet in the mountain regions, must be able to withstand almost every conceivable variation of climatic conditions. (See map, fig. 7.) So far as the influence of temperature is concerned, it is only in the most unprotected situations that severe winter weather appears to have much effect in regulating the abundance of the pest, although frequent freezing and thawing is known to be fatal to a large percentage of the adults if these occur in exposed situations. Thus temperature may practically be eliminated from consideration. It is also true that the nearly developed insect will withstand not only the humidity of the Tropics, but continuous drenching rains of more northern latitudes. It is at the time of hatching that the species is most susceptible to meteorological conditions. Frequent drenching rains during the hatching season are fatal to the pest almost to the extent of extermination, and it is due

to this more than to any other influence that the chinch bug is kept within the limits of its present abundance and destructiveness. It matters little how great a number of these insects pass the winter in safety, provided there are sufficiently prolonged, drenching rains

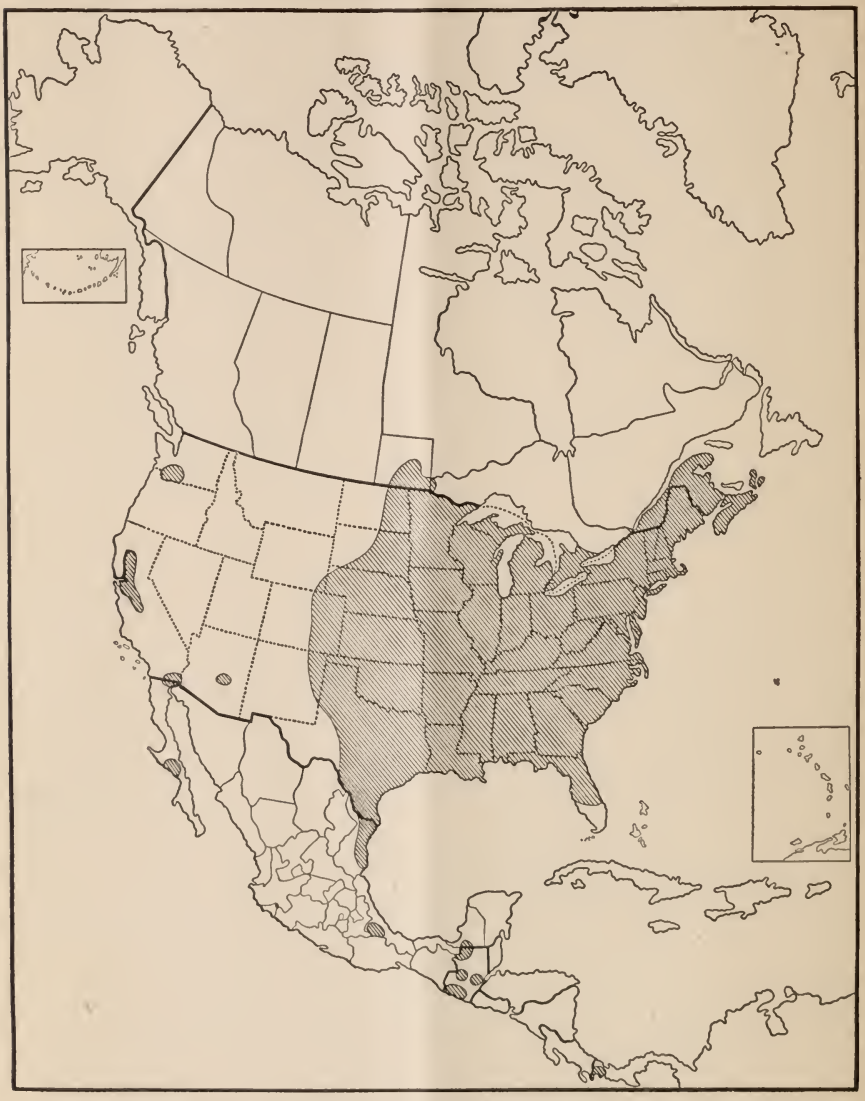

FIG. 7.—Map of North America showing areas infested by chinch bug. (Author's illustration.)

during the hatching period. Again, with an excessive abundance of individuals developing from the first generation, if at the time of the hatching of the young of the second generation there are frequent drenching rains, an outbreak the following year is prevented. Thus it is that although an outbreak may seem inevitable as the

season for the ravages of the chinch bug draws near, there is often a radical reduction instead of an increase in numbers. The forecasting of chinch-bug outbreaks is therefore based wholly upon the forecasting, months in advance, of meteorological conditions that are likely to occur at certain periods. If the farmer would but watch the seasons, he need not be taken unawares by chinch-bug outbreaks, as dry weather during the two breeding seasons is usually sufficient to precipitate an invasion the following year, provided that, at the critical period or time of hatching, rains do not destroy the young. The general statement may be made that throughout the Middle West a dry June followed by a dry August is favorable for the development of chinch bugs. These dates will of course vary, and must not be applied to the more southern or more northern localities.

PARASITIC FUNGI.

The fact that the abundance and consequent influence of fungous enemies of the chinch bug are almost entirely dependent upon meteorological conditions is sufficient to place them in a secondary position, even though they may, under favorable weather conditions, act as natural checks.

Dr. Henry Shimer[a] long ago made the truthful and important statement that "this disease among the chinch bugs was associated with the long-continued wet, cloudy, cool weather that prevailed during a greater portion of the period of their development." These are precisely the conditions under which these fungi have been observed to prove the most fatal to the chinch bug during recent years where their introduction among the host insects was accomplished by artificial means. Although Shimer probably never anticipated the artificial cultivation of his "disease" and the results which have since been obtained from its artificial dissemination in the fields, yet his careful and painstaking studies must ever be associated with the application of fungous diseases in the destruction of insects in America.

The principal fungus to be artificially employed in destroying chinch bugs has come to be known as the chinch-bug fungus (*Sporotrichum globuliferum* Speg.), and this is the one used by Doctor Snow in Kansas for artificial introduction into localities where there is an overabundance of these bugs.

Doctors Roland Thaxter and S. A. Forbes devised a method of artificial cultivation, the latter using a basis of sterilized mixture of beef broth and corn meal. As this fungus has many other host insects, it is probably present to a greater or less degree throughout the country every year. There is no doubt that during wet weather

[a] Proc. Acad. Nat. Sci. Phila., May, 1867.

considerable benefit may be derived from the artificial cultivation and application of this fungus, but its efficiency is very dependent upon this meterological condition, and, as has already been shown, chinch bugs develop in the greatest abundance in dry seasons. It will thus be seen that only during unusual seasons—that is to say, seasons that have been dry while the chinch bugs were hatching from the eggs but wet afterwards—can satisfactory results be expected from this measure.

The effects of this fungus have probably been overestimated, although there is no doubt whatever that those who have been most instrumental in popularizing this means of destroying chinch bugs were thoroughly sincere and honest in their statements. One very important element of deception to the ordinary farmer, when assuming the results of the effect of this fungus, lies in the fact that chinch bugs, when molting for the last time and passing from the last-stage larva to the adult, hide away under the sheaths of corn and other grain, and, casting the larval skin, make their escape, leaving this behind. These cast skins will occur in immense numbers in such places and frequently become covered with a white mold. It is almost impossible for anyone except an expert to distinguish the difference between chinch bugs that have been actually killed by this fungus and the mass of cast skins covered with ordinary mold. The uncertainty as to the effects of this fungus is responsible for its having fallen largely into disuse during recent years. It will thus be seen that this whole matter hinges upon meteorological conditions which are, as has been stated, most powerful factors in holding the chinch bug continually in check, and it is following a succession of dry seasons that the pest commences to become destructive. During seasons of excessive abundance of chinch bugs, this fungus will almost invariably appear among them in the fields, provided that at this time there occurs a considerable period of wet weather.

REMEDIAL AND PREVENTIVE MEASURES.

All remedial and preventive measures that have been found to possess the merit of reasonable efficiency and practicability are discussed in the following pages. These may not all prove applicable in all localities or under every variety of circumstance, and the farmer will often have to adapt his protective measures to weather conditions, location of field and its surroundings, and to the thousand and one other variations of a similar nature.

DESTRUCTION OF CHINCH BUGS WHILE IN HIBERNATION.

The first effort that may be made with a view to warding off an attack of chinch bugs is to destroy them in their winter quarters.

This can be accomplished by burning all dried grass, leaves, or other rubbish during winter or early spring. The burning of all such grass will destroy thousands of bugs in their winter quarters; but sometimes the matted bluegrass remains green in winter, or the weather is not sufficiently dry to enable the farmer to burn over such places. In such cases a flock of sheep, if given the freedom of the fields during winter and spring, will eat off all living vegetation and trample the ground with their small feet, so that not only is all covering for the bugs removed, but also the bugs are crushed to death. So it is with the matted grass along roadsides and fences,

FIG. 8.—Poorly kept roadside with rail fence overgrown with brambles, thus affording protection for large numbers of destructive insects during winter. (Author's illustration.)

especially the Virginia worm rail fence (fig. 8). The ease with which the narrow strip of grass land along a post-and-wire fence can be kept free of matted grass and leaves, as compared with that along a hedge or rail fence, indicates that there may be an entomological factor connected with the modern fence that has been overlooked, giving it, in this respect, an advantage over the more ancient form. A good illustration of the fact that large numbers of chinch bugs may be in hiding among fallen leaves in woods and other places and escape detection is shown by the fact that a quantity of dried leaves from about a vineyard located on a narrow neck of land about a quarter of a mile from the Bay of Sandusky on the one side, and about 1½

miles from the shore of Lake Erie on the opposite side, was collected late in April. At the time of collecting the leaves only an occasional chinch bug was to be observed, but under a warm atmosphere they began to bestir themselves, and soon demonstrated that there had been a large number ensconced unseen among the dried and curled, dead grape leaves.

Shocks of fodder corn, left in the fields over winter, certainly afford protection for many chinch bugs, as will also coarse stable manure spread on the fields before the chinch bugs have selected their place of hibernation in the fall. In short, the first protective measure to be carried out is a general cleaning up in winter or early spring either by burning, or pasturing, or both.

SOWING DECOY PLATS OF ATTRACTIVE GRAINS OR GRASSES IN EARLY SPRING.

Judging from the manner in which the overwintered adults are attracted to hills of young corn, wheat fields, or plats of panic and foxtail grasses, it has always seemed to the writer practicable to take advantage of this habit and sow small patches of millet, Hungarian grass, spring wheat, or even corn, early in the spring and thus bait the adults as they come forth from their places of hibernation. Their instincts will prompt them to seek out the places likely to afford the most desirable food supply for their progeny, and, if an artificial supply can be offered them that will be more attractive than that furnished by nature, the bugs will certainly not overlook the fact, but will take advantage of it to congregate and deposit their eggs there, whereupon eggs, young, and adults can, a little later, be summarily dealt with by plowing both bugs and their food under and harrowing and rolling the ground to keep the former from crawling to the surface and escaping. The writer has thoroughly tested this method in a case where the bugs, young and old, had taken possession of a plat of neglected ground overrun with panic grass (*Panicum crus-galli*), which was mown and promptly removed and the ground plowed, harrowed, and rolled before the bugs could escape, thus burying them beneath several inches of soil, out of which they were unable to make their way. As a consequence they were almost totally annihilated, hardly 1 per cent making their escape to an adjoining cornfield.

WATCHFULNESS DURING PROTRACTED PERIODS OF DROUGHT.

It has always appeared to the writer as though a little watchfulness on the part of farmers during periods of drought might enable them to determine whether or not chinch bugs were present in any considerable numbers in their fields in time to interpose a strip of millet between the wheat and corn, to be utilized later as previously indi-

cated. Instances have come under observation where, in wheat fields overgrown with panic grass and meadow foxtail, the bugs transferred their attention to these grasses as soon as the wheat was harvested. In such cases a prompt plowing of the ground would have placed the depredators beyond the possibility of doing any serious injury. If the weather at the time is hot and dry, a mower may be run over the stubble fields or along the borders of them, cutting off grass, weeds, and stubble, as the case may be, leaving them to dry in the hot sun, when, in a few hours, they will burn sufficiently to roast all bugs among them, and, while not destroying every individual, this will reduce their numbers to such an extent that they will be unable to work any serious injury.

DIFFICULTY OF REACHING CHINCH BUGS IN MEADOWS.

There is, however, some doubt in regard to the practicability of applying these measures in timothy meadows. Meadow lands can be burned over with perfect safety to either the grass or clover, if done while the ground is frozen, but there is danger of injury if burned over in spring, and it is somewhat doubtful if the hibernating chinch bugs would be killed unless the surface of the ground was heated to a degree that the grass and clover plants would hardly be able to withstand.

Infested areas of meadow land could be plowed, it is true; but the work would have to be done very carefully, else the grass and stubble would be left to protrude above ground along each furrow and constitute so many ladders by which the chinch bugs could easily crawl out and make their escape. Where the ground will admit of subsoiling, or where a "jointer" plow can be used, this latter difficulty can be easily overcome. Usually, however, the chinch bugs work too irregularly in a field to permit of plowing under infested areas without disfiguring the field too much for practical purposes, especially in the case of meadows, unless it be where the bugs have migrated en masse from an adjoining field, when a narrow strip along the border can often be sacrificed to good advantage. In many instances the drastic measure of turning under a few outer rows of corn with the plow would have saved as many acres from destruction. In the majority of cases it is the fault of the farmer himself that these measures are not effective, as he will seldom take the trouble to burn the dead leaves, grass, and trash about his premises at the proper time, and when there occurs an invasion of chinch bugs, instead of resorting to heroic and energetic measures to conquer them on a small area, he usually hesitates and delays in order to determine whether or not the attack is to be a serious one, and by the time he has decided which it is to be the matter has gone too far, and the chinch bugs have taken possession

of his field. This is especially true in the West, where the bugs breed exclusively in the fields of wheat and remain unobserved until harvest, when they suddenly and without warning precipitate themselves upon the growing corn in adjacent fields. In fighting the chinch bug promptness of action is about as necessary as it is in fighting fire.

ELIMINATING CHINCH BUGS FROM TIMOTHY MEADOWS BY CROP ROTATION.

In several instances where chinch bugs have become especially destructive to timothy meadows over considerable areas of country, it has been found that these outbreaks were attributable to the fact that these sections of country were largely given over to dairying. The dairymen and stockmen found it more desirable to allow timothy pastures and meadows to remain more or less permanent, with the result that the chinch bugs gradually became so excessively abundant as to destroy the grasses on these areas. In a number of instances it was found that where the prevailing agricultural methods were changed and the infested grass lands were broken up and devoted to other crops, the difficulty was eliminated, as the new meadows were not attacked. This shows that throughout the country where the short-winged chinch bug attacks timothy meadows a rotation crop will be found an efficient measure in overcoming the difficulty with a reasonable degree of permanency.

UTILITY OF KEROSENE IN FIGHTING CHINCH BUGS.

In fighting the chinch bug there is at present no more useful substance than kerosene, either in the form of an emulsion or undiluted. From its penetrating nature, prompt action, and fatal effects on the chinch bug, even when applied as an emulsion, it becomes an inexpensive insecticide, while it has the further advantage of being an article universally found in every farmhouse, and is therefore always at hand for immediate use. The emulsion has the further advantage of being capable of sufficient reduction in strength to preclude injury to the vegetation while still strong enough to be fatal to insect life. Diluted and ready for use, the emulsion is prepared as follows: Dissolve one-half pound of hard soap in 1 gallon of water, preferably rain water, heated to the boiling point over a brisk fire, and pour this suds while still hot into 2 gallons of kerosene. Churn or otherwise agitate this mixture for a few minutes until it becomes of a creamlike consistency and, on cooling, forms a jellylike mass which adheres to the surface of glass without oiliness. For each gallon of this emulsion use 15 gallons of water, mixing thoroughly. If applied to growing corn, it will be best to use the emulsion either during the morning or evening, say before 8 a. m. or after 5 p. m., as at these times it will be less likely to affect the plants than if applied in the heat of the day.

Where an invasion of the chinch bug is in progress from a field of wheat to an adjoining field of corn, as an illustration, the marginal rows of corn can be frequently saved, even after the bugs have massed upon the plants, by spraying or sprinkling them freely with kerosene emulsion, being careful not to get much of it directly into the crown of the plants and using a sufficient quantity so that the emulsion will run down the outside and reach such bugs as are about the base of the plants. This treatment will kill the bugs clustered upon the corn, and in case of those on the way to the field, while it will not keep them out, it will cause a halt in the invasion, and thus give the farmer an opportunity to put other measures in operation, one of which will include the use of kerosene in another manner. If a deep furrow is plowed along the edge of the field, running the land side of the plow toward the field to be protected, the furrow will form a temporary barrier to the incoming hordes.

UTILITY OF DEEPLY PLOWED FURROWS SUPPLEMENTED BY THE USE OF KEROSENE EMULSION.

In dry weather the sides of the furrow can be made so steep and the soil so finely pulverized that when the chinch bugs attempt to crawl up out of the furrow they will continually roll back to the bottom, where they can be sprinkled with either kerosene alone or with the much less expensive emulsion and killed. In case of showery weather, which prevents the sides of the furrow from remaining loose and dry, the bottom can be cleared out with a shovel, making it more smooth and the sides more perpendicular, thus rendering it so much easier for the bugs to follow along the bottom than to attempt to climb the sides. If holes are dug across the bottom at distances of, say, 30 or 40 feet, the bugs will fall into them and can be still more easily disposed of by the use of kerosene. That both of these measures are thoroughly practicable the writer can attest by ample personal experience, and he knows that under most conditions that are likely to obtain prompt and efficient application is all that is necessary. During a few days this work will demand the closest watching and application, but fields of grain can be protected thoroughly and effectually if these measures are faithfully carried out, and the expense of time and money will be found to be less than in almost any other plan that has been discovered up to this time. In no case has a field attacked by a migrating army of chinch bugs come under the writer's observation but that might have been saved from very serious injury by the prompt use of either of these measures, though under some conditions the farmer might find it advantageous to apply some of the other methods of protection here given. In all of the following methods crude petroleum may be substituted for coal tar if the former is more easily obtainable.

THE SURFACE AND COAL-TAR METHOD.

The objections made by farmers to the use of most of these barriers is that the finest pulverized soil soon becomes incrusted by even the slightest rainfall and the bugs then pass over it without difficulty, while barriers of boards are expensive. It is feasible to eliminate both by simply smoothing off a path along the margin of an infested field where such an one adjoins the one to be protected. This can be done with a sharp hoe, and as the margins of wheat fields usually become compacted, it is but little trouble to thus clear off a path a foot or more in width, smooth as a floor, with the surface almost as hard. Along this path circular post holes are sunk, as in the bottom of furrows, and a train of coal tar is run between them, being so arranged that it will reach the post hole at the edge farthest from the field from which the bugs are migrating. The bugs, on reaching the train of coal tar, will follow along until they reach the post hole, while those meeting with the post hole will usually divide and, following around it, join with the flow of bugs moving along the train of coal tar. The result is that they become congested in the acute angle where the coal-tar train is intercepted by the post holes. Those in the apex of this angle can not turn back, and thus are continually pushed into the post holes by those behind. As the bugs, varying from the red larvæ of the younger stages to the almost black ones of the last stage, mass along the line of coal tar, they have much the appearance of a reddish-brown stream running into the holes. From these holes there is no escape and here the bugs can readily be killed by sprinkling with kerosene. The slightest train of coal tar is sufficient to obstruct the passage of the bugs, and light rains will not affect its efficiency. In dry weather these trains of coal tar soon become covered over with dust and must be renewed; but in showery weather there is no dust, and if the coal tar is renewed daily or, at most, twice each day, it will accomplish its work and nothing further will be needed than to kill the bugs that have collected in the post holes. This measure is inexpensive and can be promptly put into operation if the coal tar is at hand. The writer has been able in this way to effectively protect a field of corn bordered on two sides by a wheat field literally overrun with chinch bugs at harvest and during a time when light showers were occurring, frequently several times each day.

THE RIDGE AND COAL-TAR METHOD.

Differing quite materially from the preceding are the various combinations of coal tar and ridges of earth, smoothed and packed along the apex, or, instead of the ridge of earth, 6-inch boards, such as are ordinarily used for fencing, placed on edge and the upper edge coated

with tar. Forbes has reported excellent results from the application of a line of coal tar put directly upon the bare ground where the surface has been rendered compact by a recent fall of rain. Even in this series of protective measures kerosene can be used to great advantage. In the experiment recorded by Professor Forbes the coal tar was put upon the ground between a wheat field and a cornfield from an ordinary garden sprinkling pot from which the sprinkler had been removed and the orifice of the spout reduced in size with a plug of wood until the tar came out in a stream about the size of the little finger and made a line on the surface of the ground about three-fourths of an inch in width. Post holes were sunk along the line from 10 to 20 feet apart on the side next to the wheat field, thus practically completing the barrier, and the chinch bugs, being unable to cross the line of tar, accumulated in the post holes in vast numbers, where they were killed, and those bugs that had already entered the cornfield before the barrier was constructed were prevented from spreading farther by tar lines between the rows of corn, the infested corn itself being cleared of bugs by the application of kerosene emulsion. The same writer states[a] that several farmers in Vermilion County, Ill., prepared for the coal-tar line by hitching a team to a heavy plank and running this, weighted down with three or four men, over the ground once or twice until a smooth, hard surface had thus been made to receive the tar. If the barrier was to be made in sod, a furrow was plowed and the bottom of this made smooth by dragging the plank along the bottom. In both cases post holes were sunk along the tar lines, and in these were placed cans or jars into which the bugs fell in myriads and were destroyed.

On one farm of 250 acres a coal-tar line 90 rods in length was renewed once each day and killed about 8 gallons of chinch bugs. In the case of another farmer there were 300 rods of tar lines with post holes, cans, etc., which resulted in destroying about 10 bushels of chinch bugs. A 6-gallon jarful was destroyed in less than half a day at one point on the line. In this last instance the lines of tar were renewed three times a day, but even then less than a barrel of tar was used. Still another farmer, with 120 rods of tar line, used about a third of a barrel of tar and did not lose a hill of corn; he caught chinch bugs by the bushel. In some of the cases cited the tar line was run in a zigzag course, the post holes being situated at the angles, and in others leader tar lines were run obliquely to the main tar line, one end terminating at the traphole, but both of these plans were afterwards regarded as unnecessary, a single straight line being entirely sufficient and less expensive. The numerous cases where these methods were put into execution with entire success and

[a] Twentieth Report State Entomologist of Illinois, p. 39, 1898.

at small expense afford the best possible proof of their practical utility. If a farmer is situated near town, where refuse tin cans are dumped in any locality where they can be got out of the way, he can select the larger of these, set them in the post holes and partly fill them with kerosene and water. The water, being heavier than the kerosene, will sink to the bottom, leaving a stratum of kerosene on the surface. The chinch bugs falling into this will be forced down by the weight of those coming after, and thus all will be passed through the kerosene into the water below. This will obviate the necessity of frequently emptying the cans or treating their contents. It may also be stated that where the post holes are quite deep and enlarged at the bottom the bugs falling into them will perish without further attention.

OTHER BARRIER METHODS.

The late Professor Snow, working in Kansas, followed a somewhat different method, and one that, under certain conditions, might be found superior to that used by Professor Forbes, or the furrow and kerosene method applied by the writer in Ohio. This modification consists in throwing up a double furrow, known among farmers as "back furrowing," and thus forming a ridge, the top of which is smoothed and packed with a drag having a concave bottom of the form of the ridge to be made. If the bottom of this drag is covered with zinc, it will be found to keep bright and polished, and by this means make a smoother ridge. Along the top of this ridge is run a train of coal tar as it came from the gas works, or crude petroleum as taken from the oil wells. The former is more easily obtained, except in certain localities, and will probably be found the more practical, as it stands on the surface better and is not so readily washed away by rains. Both of these substances are, however, offensive to the bugs, and they will seldom attempt to cross them or even come close enough to touch them, but on approaching will turn and run along the ridge in the evident hope of finding a gap through which they can pass. Post holes were dug on the outside of the line, but close up to it, so that the bugs in passing along beside the tar line would crowd each other into them. Professor Snow suggested that it will be better to construct this barrier several weeks prior to the time when it will be needed, as then the tar line has but to be run along the ridge, and the post holes dug, when the whole system is complete, and the chinch bugs can be thus shut out from the first.[a]

With these barriers of either ridge or furrow and the use of coal tar or crude petroleum, supplemented by kerosene emulsion, a very large percentage of the injury from chinch bugs may be obviated,

[a] Fifth Annual Report of the Director of the Experimental Station of the University of Kansas, for the year 1895 (1896), pp. 45–47.

and, in fact, with a reasonable degree of watchfulness and prompt action, all injury from migrating hordes may be prevented. The use of tarred boards set on edge or slightly reclining might, under some circumstances, take the place of the ridge or furrow, but these cases will be exceptional, and the use of kerosene emulsion will probably be found equally practicable here, as also will the post holes for collecting the chinch bugs. This method is merely cited in order to call attention to its possible use where the others are found impracticable.

THE USE OF FURROWS WITHOUT PETROLEUM OR COAL TAR.

The plowing of furrows has been in vogue since the first writings of Le Baron and the second report of Fitch, and may be utilized in other ways than those previously mentioned. A heavy log dragged back and forth in this furrow will pulverize the soil in dry weather, and Doctor Forbes has recorded the fact that where this furrow has a temperature of 110° to 116° F. it is fatal to the young bugs that fall into the furrow, even if they are not killed by the log. As 120° is not uncommon in an exposed furrow on a hot summer day, it will be observed that there may be cases where this method will be found very serviceable, and especially is this likely to prove true in a sandy soil with a southern exposure. In sections of the country where irrigation is practiced, these furrows may be flooded and in this way rendered still more effective without the expenditure of either time or money to keep them in constant repair. Riley long ago laid considerable stress on this measure, believing it of much value, especially in the arid regions of the far West. The same writer advised the flooding of infested fields, wherever it could be done, for a day or so occasionally during the month of May. It is hardly probable, however, that this will often be found feasible except in rice fields, where it is sometimes practiced.

NECESSITY FOR PREVENTING CHINCH BUGS FROM BECOMING ESTABLISHED IN FIELDS OF WHEAT AND GRASS.

In the foregoing it will be observed that prevention of migration has been the chief end in view, either by destroying the chinch bugs in their hibernating quarters, and thus preventing the spring migration to the breeding places, or by various traps and obstructions to prevent them from migrating from such places to others not already infested. The great problem remaining to be solved is to prevent their breeding in wheat fields at all. As has been shown, it is absolutely impossible, with our present inability to forecast the weather months in advance, to be able to foretell whether or not an outbreak of chinch bugs is likely to take place. There may be an abundance of bugs in the fall—enough to cause an outbreak over a wide section of country—and these may overwinter in sufficient numbers to cause some injury

in spring, yet a few timely, drenching rains will outbalance all of these factors, and our wisest prognostications fail of proving true. It is this very factor of uncertainty that renders unlikely the successful carrying out, over any large area of country, of any protective measures, where, as in this case, the benefit to be derived will only be realized nearly a year afterwards, if at all. The average farmer, when smarting under a heavy loss, will often take such long-range precautions as to sow belts of flax, hemp, clover, or buckwheat around his wheat fields once; but if the chinch bugs do not appear, and he sees the useless investment of time, labor, and seed, he will be likely to conclude next year to take the risk and do nothing. For the present, then, we have no method whereby we can prevent the chinch bugs from taking up their abode in wheat fields or timothy meadows and raising their enormous families there, except to destroy the adults in their winter quarters.

The writer once tried to destroy the young in a wheat field by spraying with kerosene emulsion the small areas of whitening grain that indicated where the pests were massed in greatest abundance. The result was unsatisfactory, and it is very doubtful if it is possible to apply this measure with any degree of success, and we are forced to the conclusion that, for the present at least, we shall be obliged to rely upon the measures previously given. It therefore becomes of the utmost importance to clean up the roadsides, and the ground along fences and patches of woodland, as well as any other places likely to afford protection for the hibernating chinch bugs. There are, of course, obstacles in the way of carrying out this plan generally over any large area of country, and especially in sections where the rail fence predominates. But as the country gets older it will be found that it is not chinch bugs alone that seek these places in which to pass the winter, but myriads of the other insect foes of the farmer as well, and that careful attention to the condition of roadsides, lanes, hedgerows, and waste places about the farms, during the season when insects seek out these places wherein to pass the winter, will pay well for the time expended in that direction. It may come about that some phase of the street-cleaning reform may invade the country, and it is certain that if such were to occur it would, in time, save the country enough to go far toward reducing the expense of securing good roads. In fact, the term "good roads" ought to include the proper care of the roadsides, as well as the grading and macadamizing of the roadbeds themselves.

There are at present so-called "weed laws" in many States, and, though more or less of a dead letter in most cases, these laws are steps in the proper direction. The time when insect pests will be looked upon in the eye of the law as so many public nuisances, and

the harboring of them a corresponding crime, may be a long way off, but as it gradually draws nearer we shall come to learn that after all it is the rational view to take and will go far toward solving not only the chinch-bug problem but many others of a similar nature. So far as the chinch bug is concerned, when we burn over the waste lands and accumulated rubbish about our farms in autumn or winter, we are simply applying the same check that the dusky savage did when he lighted the prairie fires, though unwittingly and for an entirely different purpose. In the timothy meadows of the northeastern portion of the country, where, for lack of wings fitting it for locomotion, the chinch bug does not so largely migrate to the waste lands in autumn, the problem is somewhat different, and it will require some careful experiments to determine the exact effects both on the hibernating chinch bugs and on the grass roots of burning over the meadow lands in winter. There can be little doubt, however, that a rapid rotation of crops, so as not to allow the short-winged form to become thoroughly established in a meadow, and the burning over of waste places, thus destroying such rubbish and débris as will serve to offer hibernating places for the long-winged form, will go far toward settling the chinch-bug problem in grass lands.

As previously stated, the chief drawback in putting preventive measures in force is the difficulty of foretelling an invasion. In northeastern Ohio in 1897 hundreds of acres of timothy meadow were destroyed after the hay crop had been removed, but so late that the farmers did not suspect the true condition of their meadows until the spring of 1898, when the young grass failed to put forth and an examination revealed the fact that the roots had been killed, the abundance of chinch bugs pointing unerringly to the cause of the trouble, though in many cases a heavy crop of hay had been removed the previous year where now the ground was entirely bare. While in the case just cited a previous knowledge of the presence of chinch bugs in these meadows might not have enabled the owners to have saved them in the fall of 1897, yet the fall plowing of the land, possibly early enough to have sown the ground to fall wheat, would have buried the majority of the bugs so deeply in the soil as to have killed vast numbers of them and thus prevented their migrating to other lands in the spring of 1898. A rotation of crops that would have included grass for not to exceed two successive years, followed by wheat, would have amounted to precisely the same remedial measure as the one suggested.

A case in northeastern Ohio has come to the writer's notice where an infested timothy meadow was plowed late in the fall of 1897. Late in April of 1898 this ground was cultivated, rolled, and harrowed

several times and most carefully and completely prepared for corn, which was planted, but with the result that a portion of the field was attacked and destroyed by chinch bugs, largely of the short-winged form. An examination about June 10 revealed the bugs in considerable numbers about the plants still remaining, but scattered over the field were more or less numerous clumps of timothy, in some cases apparently killed by the chinch bugs, while in others the bugs were literally swarming about the dying but still green clumps of grass, thus showing that they had either not been buried by the plowing and cultivation of the ground or else the grass had not been thoroughly covered, and thus ladders had been left whereby the bugs were enabled to climb to the surface.

SUMMARY OF REMEDIAL AND PREVENTIVE MEASURES.

In summing up the matter of remedial and preventive measures for the control of the chinch bug, it may be stated that the insects can be destroyed in their places of hibernation by the use of fire. They can, under favorable meteorological conditions, be destroyed in the fields, if present in sufficient abundance during the breeding season, by the use of the fungus *Sporotrichum globuliferum*, if promptly and carefully applied. They can be destroyed while in the act of migrating from one field to another by tarred barriers or deep furrows supplemented by post holes and by burying them under the surface of the ground with the plow and harrow, or the latter method may be applied after the bugs have been massed upon plats of some kind of vegetation for which the bugs are known to have a special fondness, these decoy plats being so arranged as either to attract the females and induce them to oviposit therein or to intercept an invasion from wheat fields into cornfields. When these decoys have been turned under with a plow and the surface immediately smoothed and packed by harrow and roller the bugs will be destroyed, while in the cornfields they can be destroyed on the plants by the application of kerosene emulsion. Without vigilance and prompt action, however, only indifferent results are to be expected from any of these measures.

PROSPECTS OF A FUTURE OUTBREAK.

The past history of the chinch bug in America indicates a series of years of the insects' abundance and destructiveness, followed by periods of comparative immunity from its attacks. For a number of years there have been no serious ravages and, in fact, until within the past two years the pest has hardly been noticed by farmers; but within the last year (1908) there have come a number of complaints of serious injury, and, while these outbreaks have so far been of a rather localized character, they seem nevertheless to betoken the

drawing to an end of the period of immunity and the beginning of a series of years of abundance and destruction. These somewhat portentous reports have come from the farmers of Ohio, Indiana, Illinois, Kansas, and Texas. Strangely enough, the city man has not been allowed to rest unmolested and reports of serious ravages by chinch bugs on lawns have come from the widely separated points, Brooklyn, N. Y., and Palm Beach, Fla. It is because of these ominous reports that this publication has been prepared at this time with the hope not only of sounding a note of warning, but also, if possible, of impressing upon the farmer the necessity of watchfulness and the prompt application of preventive measures where the insect is found to occur in any considerable numbers. The Bureau of Entomology has the present summer (1909) been carrying out much experimental and demonstrative work in the West, notably in Kansas.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *September 16, 1909.*

[Cir. 113]

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